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ABSTRACT

This booklet, one of a series developed by the Frederick County Board of Education, Frederick, Maryland, provides an instruction module for an individualized or flexible approach to secondary science teaching. Subjects and activities in this series of booklets are designed to supplement a basic curriculum or to form a total curriculum, and relate to practical process oriented science instruction rather than theory or module building. Included in each booklet is a student section with an introduction, performance objectives, and science activities which can be performed individually or as a class, and a teacher section containing notes on the science activities, resource lists, and references. This booklet reviews the basic principles of genetics. The estimated time for completing the activities in this module is two weeks. (SL)

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Genetics

AIDS TO INDIVIDUALIZE THE TEACHING OF SCIENCE

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MINI-COURSE UNITS

BOARD OF EDUCATION OF FREDERICK COUNTY
1974

Marvin G. Spencer

SE 021 634

GRAPHIC ARTS DEPARTMENT - F.H.S.

BASIC PRINCIPLES OF GENETICS

Prepared by

Sharon L. Sheffield

Estimated Time for Completion

2 weeks

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Mini Courses for

Physical Science, Biology, Science Survey,

Chemistry and Physics

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FOREWORD

The writing of these instructional units represents Phase II of our science curriculum mini-course development. In Phase I, modules were written that involved the junior high disciplines, life, earth and physical science. Phase II involves senior high physical science, biology, chemistry, physics and science survey.

The rationale used in the selection of topics was to identify instructional areas somewhat difficult to teach and where limited resources exist. Efforts were made by the writers of the mini-courses to relate their subject to the practical, real world rather than deal primarily in theory and model building.

It is anticipated that a teacher could use these modules as a supplement to a basic curriculum that has already been outlined, or they could almost be used to make up a total curriculum for the entire year in a couple of disciplines. It is expected that the approach used by teachers will vary from school to school. Some may wish to use them to individualize instruction, while others may prefer to use an even-front approach.

Primarily, I hope these courses will help facilitate more process (hands on) oriented science instruction. Science teachers have at their disposal many "props" in the form of equipment and materials to help them make their instructional program real and interesting. You would be remiss not to take advantage of these aids.

It probably should be noted that one of our courses formerly called senior high physical science, has been changed to science survey. The intent being to broaden the content base and use a multi-discipline approach that involves the life, earth and physical sciences. It is recommended that relevant topics be identified within this broad domain that will result in a meaningful, high interest course for the non-academic student.

ALFRED THACKSTON, JR.
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BASIC PRINCIPLES OF GENETICS

The study of the basic principles controlling the production of characteristics or traits in successive generations of living things is one of the most interesting developments of this century. Man has always been aware of and noted the continuity and variability of the characteristics of living things. He has speculated as to the cause of these variations. However, it is only in relatively recent years that he has developed any real understanding of the principles involved in the inheritance of these characteristics.

All of us know some of the basic rules of heredity. For instance - you have observed that dogs produce puppies, cats produce kittens, cows produce calves and people produce people. You have also observed that while several puppies, kittens,etc. may be produced at one time and all have the basic characteristics which make them puppies (species characteristics), each one of these individuals has special traits (individual characteristics) which make them different from each other. One of the things you may not have realized is that both likenesses and differences among individuals can be correlated with the relationships between them.

The biological relationship is only part of the reason for similarities and differences between individuals. Individuality is the result of an interaction between heredity and environmental factors. The effects of these influences vary from trait to trait and circumstance to circumstance.

The science of genetics studies the contributions of heredity and seeks to analyze the principles and laws governing the action of the biological factors. This is what you will investigate in this unit of work.

A. The Work of Gregor Mendel

OBJECTIVES

The student will be able to:

1. summarize the work of Gregor Mendel and relate its importance to the field of genetics.

2. explain and diagram these basic genetic principles:
   - -Concept of unit characters
   - -Principles of dominance and recessiveness
   - -Law of segregation
   - -Law of independent assortment

ACTIVITIES

These will aid you in understanding the objectives.

a. Read Chapter 9 of the 1969 edition of Modern Biology or the reference chapter assigned.

b. Complete part A of Mendel's Laws of Heredity (see separate sheet).

c. Continue using your resource chapter, this time concentrating on the conclusions Mendel reached with his plants. Use this information to complete parts B, C, D and E of Mendel's Laws of Heredity.

d. Complete Lab 9-2 Study of Mendelian Laws and Principles (on separate sheet).

MENDEL'S LAWS OF HEREDITY

Part A. Gregor Mendel

1. Why is Gregor Mendel famous? _____

_____

2. List the dates (approximate) of his most important experiments.

_____

3. When were his results widely recognized by scientists? _____

_____

4. What plant did Mendel use in most of his experiments? _____

_____

5. List four traits Mendel studied in these plants.

a. _____ c. _____

b. _____ d. _____

6. Explain how the following precautions helped Mendel come to sound, scientific conclusions:

a. The constant use of controls

b. Accurate and complete records

c. Large numbers of subjects used in collecting data

7. What is genetics? _____

_____

Part B. Law of Unit Characters

As Mendel worked he realized that each character was inherited independently of the others - in other words, not all red flowers were tall and not all white flowers were short. Some white flowered plants were tall and some were short. The same was true for red flowered plants. Fortunately for Mendel and genetics, this was the case for all the traits he studied. Mendel decided that some factor inside the plant controlled these characteristics and that the factors were separate units.

1. In your own words, rephrase the Law of Unit Characters.

2. Which is inherited, the character (such as flower color) or the tendency to produce the character?

   What is the tendency called?

3. What is a gene?

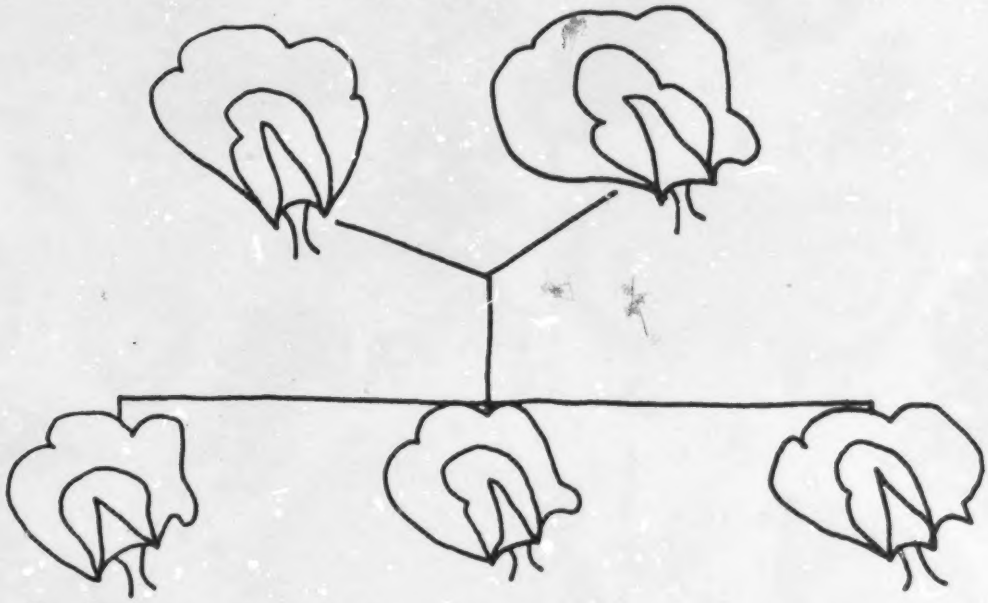
   Where are genes found?

Part C. The Law of Dominance

One of the interesting investigations Mendel did included work with two types of pea plants. One type plant had white flowers and one type plant had red flowers. Through successive generations of offspring Mendel found that certain white flowered pea plants produced only white flowered offspring, and that certain red flowered plants produced only red flowered offspring. These plants Mendel designated as pure breeds or pure strains. His next step was to cross (allow pollination between two plants to occur) pure white and pure red plants. The offspring or progeny (the plants which grew from the seeds) of this combination <u>all</u> had red flowers. There were no white flowers.

Mendel therefore concluded that while the offspring contained both factors for red and white color, the red factor masked the effect of the white factor. Mendel called the red factor the dominant factor, he designated the white factor the recessive factor.

1. The diagram below represents the experiment Mendel performed. Label the parent types and the first filial generation (sons, daughters) usually indicated with this symbol F_1. Color the diagram to correspond with the results of the experiment.



2. What does the term character mean when used in genetics?

Give an example:

3. The pair of characters in Mendel's experiment

_____ and _____,

are called _____ characters.

4. A _____ is a variety of organism which always shows the same character through each generation.

5. When two parents are pure strains of contrasting characters, the offspring are called _____. Which generation in the diagram is an example of this type organism?

6. In hybrid organisms, one of the contrasting character may mask the effect of the other. The character which masks the effect is said to be _____, the other is said to be _____.

7. In Mendel's experiment, it was discovered that red flowers were a

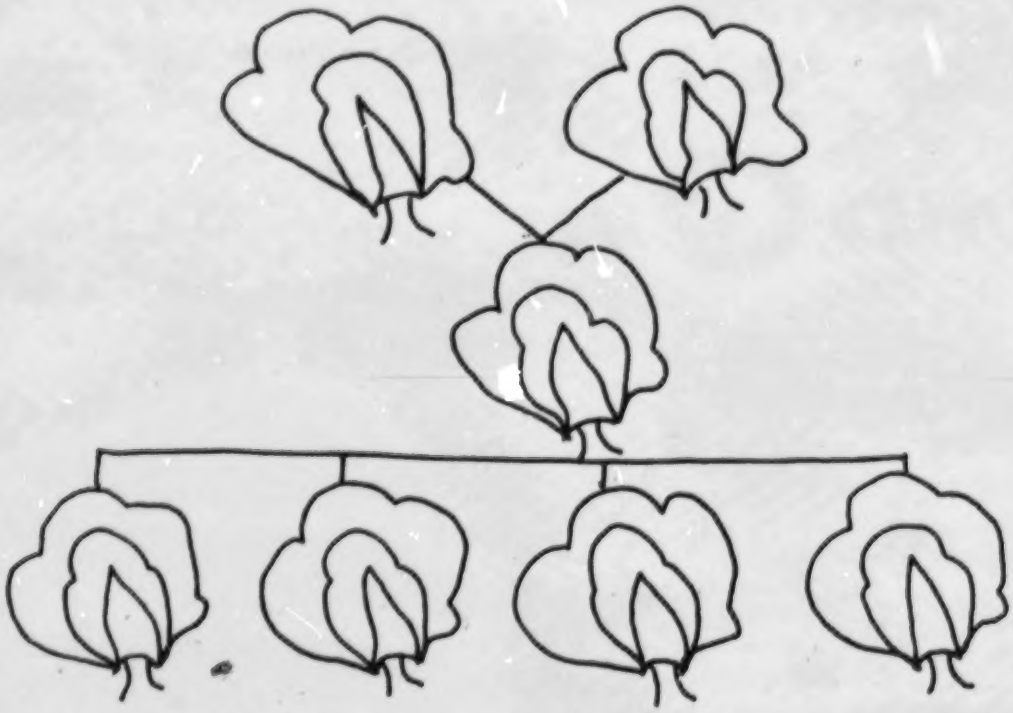
_____ character and white flowers a _____

character.

Part D. The Law of Segregation

The hybrid red-flowering plants are the same in appearance as the pure red flowering plants. In genetic terminology it is said that the phenotypes (appearance) are the same. When the hybrids are allowed to pollinate each other some of the seeds produce plants with white flowers but most of the offspring are still red. When the offspring are counted, three-fourths of the plants had red flowers and one-fourth had white flowers. This indicates that the factor for white flowers had not been destroyed, just masked.

1. On the diagram label the parents, the F_1, and the F_2 generations.



2. Relate this experiment to the law of segregation

3. Were any of the offspring in the F_2 generation pure strain?_____
   How could you find out?_____
   Were any of the offspring in the F_2 generation hybrids? _____
   How could you find out? _____

   Give the percentages of the type of offspring in the F_2 generation:

   Pure red____%; hybrid red____%; pure white____%.

4. Why were there no hybrid white plants?

Part E. The Law of Independent Assortment

1. In your own words restate the law of Independent Assortment.

2. Diagram the formation of gametes for an individual with a Rr Yy genotype in which R represents the gene for round seeds, r represents the gene for wrinkled seeds, Y represents the gene for yellow color, and y represents the gene for green color. This represents a dihybrid individual - each pair of genes is located on a different chromosome. Be sure that you include all possible gamete types.

9-2
STUDY OF MENDELIAN LAWS AND PRINCIPLES

Purpose

To study Mendel's principles of unit characters and dominance and the laws of segregation, and independent assortment.

Related Information

The laws that Mendel formulated from his experiments with garden peas stand today practically unchanged. His conclusions concerning the inheritance of traits were based on the study of many generations of garden peas. Since you cannot study several generations of plants or animals during your biology course, we have provided several situations in which you can study Mendelian laws and principles of inheritance and determine the expected ratios of offspring from parents whose genotypes are provided.

Part 1 DIAGRAMMING A MONOHYBRID CROSS

The seed coat was one of the seven pairs of contrasting traits that Mendel studied in garden peas. He found that some seeds had smooth coats and others had wrinkled coats. He crossed plants having these two types of seeds to determine how the seed coat trait is inherited.

Materials

no materials or apparatus required

Procedure and Observations

The parent plants in the cross Mendel used are shown in the diagram. The plant that is homozygous for smooth seeds is designated as *SS*, while *ss* indicates that the plant is homozygous for wrinkled seeds.

(a) If the male parent is homozygous for smooth seeds, what kind of gene will be present in each sperm produced? .....

(b) Similarly, if the female parent is homozygous for wrinkled seeds, what kind of gene will the eggs contain? .....

Diagram this cross in the Punnett square marked F_1. (c) What is the genotype of the plants in the F_1 generation? .....

(d) What is the phenotype of the plants in the F_1 generation? .....

(e) How does this cross illustrate the principles of unit characters? .....

.....

(f) Of dominance? .....

.....

(g) In what way do the offspring of the F_1 generation differ from the parents? .....

.....

P ♂ Smooth Seeds X ♀ Wrinkled Seeds

	SS	ss
Female → Genes Male ↘		
F_1		

P Hybrid Smooth X Hybrid Smooth

	Ss	Ss
Female → Genes Male ↘		
F_2		

A cross involving one pair of genes with dominance

Mendel then crossed two heterozygous smooth-seed plants (*Ss*) to produce the F_2 generation. Diagram this cross in the Punnett square marked F_2. (h) What is the phenotypic ratio of the offspring? .....

(i) What two kinds of smooth-seed plants are present in the F_2 generation? .....

.....

(j) Which of Mendel's laws and principles are demonstrated in this cross? .....

.....

Part 2 DIAGRAMMING A DIHYBRID CROSS

In Part 1 you diagrammed the inheritance of a single trait. In this part you will study crosses in which two traits are involved.

Materials

no apparatus or materials required

Procedure and Observations

In the P generation shown in the diagram, the male parent is black and rough-coated and is homozygous for both of these characters (*BBRR*). Black and rough are dominant in guinea pigs. The female parent is a homozygous white, smooth-coated guinea pig (*bbrr*). Both of these characters are recessive. (a) What genes are in the sperms? .....

.....

(b) What genes are in the eggs? .....

.....

(c) What is the genotype of the F_1 generation?

.....

(d) What is the phenotype of the F_1 generation?

.....

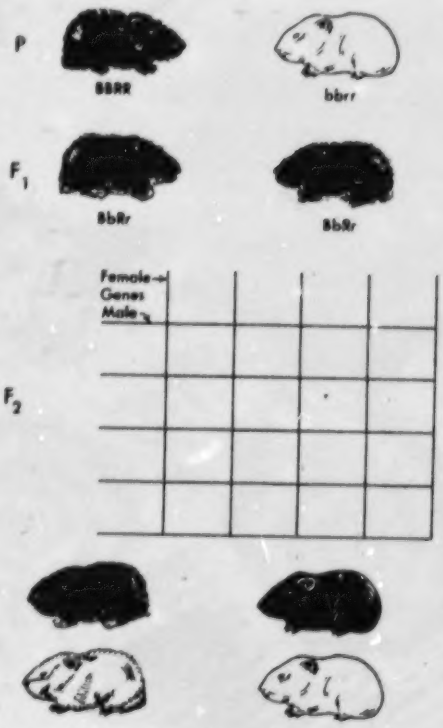
Two of the offspring of the F_1 generation are used as parents to produce the F_2 generation, as shown. Diagram the possible offspring from such a cross in the Punnett square and list the ratio of the four phenotypes below the Punnett square. (e) How does this cross illustrate the law of independent assortment? .....

.....

(f) If the genes for coat color and those for coat texture were carried on the same chromosome, would this law apply? ..... Explain your answer. .....

.....

.....



A cross involving two pairs of genes with dominance

Ratios

Black rough ..... White rough .....

Black smooth .... White smooth ....

Part 3 EXAMINING A SINGLE GENETIC TRAIT IN CORN

There are two very striking contrasting inherited characteristics found in corn seeds. One is the color of the outer layer of the endosperm (purple or nonpurple) and the other is the characteristic of the seed coat (smooth or wrinkled). When pure strains of corn producing purple seeds are crossed with pure strains of corn producing nonpurple seeds, all of the F_1 offspring have purple seeds. Furthermore, when pure strains of corn producing smooth seeds are crossed with pure strains producing wrinkled seeds, all of the F_1 offspring have smooth seeds

Materials

genetic corn showing a 1:1 ratio of purple-nonpurple (yellow or white) seeds
genetic corn showing a 3:1 ratio of purple-nonpurple (yellow or white) seeds
straight pins

Procedure and Observations

Some of the members of the class will be given ears of corn that were produced by crossing two hybrid purple parent strains; others will receive ears that were produced by crossing a hybrid purple strain and a nonpurple parent strain. You will not be told what kind of cross produced the ear of corn you have. You must determine this for yourself by counting the number of kernels of each color (purple or yellow) you find on the ear. Put a pin in the end of the row of kernels when you begin counting. Count each kernel in a row until you return to the point marked by the pin. Record your count in the table provided. *Do not pick the kernels from the ears.*

Kinds of seeds	*Number in each row*												
	1	2	3	4	5	6	7	8	9	10	11	12	*Total*
Purple													
Nonpurple (yellow)													

Determine the total number of purple and nonpurple seeds you have on your ear of corn. Record the total in the table provided. (a) What percent of the seeds were purple? .....

(b) Nonpurple? ..... (c) What is the ratio of purple to nonpurple seeds? ..... (d) Is there any evidence of purple color in the nonpurple seeds? ..... (e) Explain your answer. .....

..... (f) Although the purple seeds on both kinds of corn resemble one another in color, what evidence did you find that they may differ genetically? .....

.....

(g) List the Mendelian laws or principles illustrated in this part. .....

.....

(h) On the basis of your results, reconstruct the genetic makeup of the parents of the two kinds of ears of corn. .....

.....

Part 4 EXAMINING TWO GENETIC TRAITS IN CORN

You will not be told what kind of plants were crossed to obtain the ear of corn you have. Your counting of the characteristics (purple, nonpurple, smooth, and wrinkled) should help you determine the possible genotypes of the parents.

Materials

genetic corn showing a 9:3:3:1 ratio (purple-smooth-yellow-shrunken seeds)
straight pins

Procedure and Observations

Use the same procedure as was used in Part 3 to count and classify the seeds. Record your count in the table provided.

Kinds of seeds	*Number in each row*												
	1	2	3	4	5	6	7	8	9	10	11	12	*Total*
Purple smooth													
Purple wrinkled													
Nonpurple smooth													
Nonpurple wrinkled													

(a) How many different phenotypes did you find? .....

(b) Name these types. .....

(c) Which type appeared most frequently? .....

(d) Less frequently? ..... (e) Were the purple wrinkled seeds as common as the nonpurple smooth ones? ..... (f) Using the symbols P for purple and p for nonpurple and S for smooth and s for wrinkled, give the genotypes of the F_1 generation that produced the ear of corn you examined. .....

The two parents that produced the F_1 generation were pure strains. (g) Give the genotypes of the parents of the F_1 generation. .....

(h) Which of Mendel's laws or principles is represented in this part? .....

.....

Summary

On the basis of your results, explain how genetic principles operate according to predictable rules.

.....

.....

Name_____ Class_____ Date_____

ACTIVITY 29. What are the results of mating two hybrids?

PRE-LAB

A baby is about to be born! What are the chances that it will be a boy? From the knowledge of humans you know that the chances are roughly equal that the infant will be either a boy or girl. Thus, the sexes are almost evenly matched in numbers.

Does this mean that if a couple had four children, two will be boys and two girls? Does this mean that if the parents have one boy, the next child will be a girl? Of course not! You probably know many families where the offspring are all males or all females.

Why, then, do we say that the chances that either a boy or girl will be born are about one out of two? (These chances may also be expressed as 50% or as one-half.) The answer lies in the laws of probability and depends on the analysis of a great many happenings. One family may have five boys, but in a thousand families the total number of boys and girls will be about the same.

About the time the Civil War was ending and the American West was being opened up, an Austrian monk, Gregor Mendel, was making mathematical analyses of various traits in garden peas. Without ever having seen a chromosome, without knowing anything about genes or DNA, Mendel developed the basic laws of genetics. This is the science of heredity, which explains how the traits of living things are handed down from generation to generation.

You remember that during the process of maturation, sperms and eggs are formed by a series of reduction divisions. Each winds up with a monoploid number of chromosomes and genes. The diploid number is then restored during fertilization, when egg and sperm are united.

Let us concentrate on a single trait -- the size of a pea plant. If we know the genetic makeup (genotype) of the parent plants, we should be able to predict the genetic makeup as well as the appearance (phenotype) of their offspring-provided, of course, that we examine a great many plants.

Since most of us has neither the time nor patience of Gregor Mendel, we can speed up the process by flipping coins instead of raising plants. Suppose we use a penny to represent the male and a nickle for the female. Look at a penny. It has a head side and a tail side. Let the head represent the tall (T) trait, which happens to be dominant. The tail is then the short or recessive (t) trait. The penny can be thought of as a hybird. It can produce a sperm containing either a T or t. The same is true of the nickle. It can produce either the T or t type of an egg. (A "pure" coin would have to be two-headed or two-tailed!)

Before we see what happens when hybrids are mated (pennies and nickles, in this case), work out the answers to the few questions on the following page.

QUESTIONS -ACTIVITY 29

1. Explain the difference between genotype and phenotype. _____

_____

2. In order for an analysis to be scientifically worthwhile, what must be true of the number of events or happenings examined? _____

_____

3. What is meant by each of these terms:

dominant _____

_____

recessive _____

_____

hybrid _____

_____

LABORATORY PROCEDURE

Materials: One penny and one nickle

1. Review the results of mating two pure individuals by completing the Punnett square to the right. Assume all the male gamete (sperm nuclei in this case) contain the tall (T) trait. Assume also that all the egg nuclei produced contain the short (t) characteristic.

	T	T
t		
t		

Punnett Square

Two Pure Individuals

2. Now review the results of mating two hybrids. Half the male gametes will contain the (T) or tall trait. The other half will contain the (t) or short trait. The same will be true for the eggs. Complete the Punnett square to the right.

	T	t
T		
t		

Punnett Square

Two Hybrids

3. Toss your penny and nickie to find the gametes produced by chance and the resulting fertilizations. One hundred tosses of each coin should be enough.

You can flip both the penny and the nickle together or one right after the other.

OBSERVATIONS: If two heads come up, record this in the column TT in the first table on the next page. If a head and tail come up, mark that in the column Tt. Record two tails in the tt column.

4. In the second table, record the totals for each member of the class. If each student records his three totals on the blackboard, it will be easy for everyone to copy the results onto the table. Then add the totals for the entire class. Have a neighbor check your addition. Compare totals with some of your classmates.

OBSERVATIONS

RECORD OF 100 TOSSES		
TT (two heads)	Tt (head and tail)	tt (two tails)
Totals		

RECORD OF THE CLASS		
TT (two heads)	Tt (head and tail)	tt (two tails)
Totals		

POST - LAB

These questions will help you to interpret your results.

1. What is the expected genotype ratio of a hybrid mating?

   TT_____: Tt_____: tt_____

2. How did your results compare with the expected?

3. Were the results of the whole class closer to the expected ratio?

   _____

   If the answer is "yes", explain.

   If the answer is "no", explain.

4. What were the phenotype (appearance) ratios in your crosses?

   Tall_____ Short_____

   How do these compare with the expected?

5. Certain traits do not show dominance or recessiveness. For example, the white and red color traits in flowers like the Japanese four o'clock will blend in the offspring to produce pink flowers. Work out the theoretical results of crossing two hybrids that show this type of blending inheritance (also called incomplete dominance).

6. What can you say about the comparison of genotype and phenotype ratios in traits that blend?

B. Putting Mendel's Laws to Work

OBJECTIVES:

The student will be able to:

3. work genetic problems of both monohybrid and dihybrid crosses for both homozygous and heterozygous traits.

4. use and fill out a Punnett Square.

5. determine genotypic and phenotypic ratios for genetics problems presented to you.

ACTIVITIES:

These activities will help you to understand the objectives.

a. Complete Activity 29 "What Are The Results of Mating Two Hybrids" (separate sheet) .

b. Complete worksheet entitled "Guinea Pigs Illustrate Mendel's Laws" (separate sheet).

c. Complete "Inheritance of Two Pairs of Characters (Dihybrids)" (on separate sheet).

d. Work the genetics problems (on separate sheet) .

NAME.....DATE.....

5. EXPLANATION OF THE LAW OF SEGREGATION

It is now known that the pairs of chromosomes in the sex cells carry the factors of inheritance. In a pure-bred animal or plant, both chromosomes of a pair will have the same gene or factor. In a hybrid, however, one chromosome of a pair will have the gene for the dominant character, while the other chromosome carries the recessive gene. When sperm cells and egg cells are formed in a hybrid, and reduction division takes place, some sperms and eggs will have the dominant gene, while the others will have the recessive. If a sperm with a recessive gene fertilizes an egg with the same recessive gene, all the body cells of the resulting organism will have only those recessive genes, and the recessive character will develop in the organism.

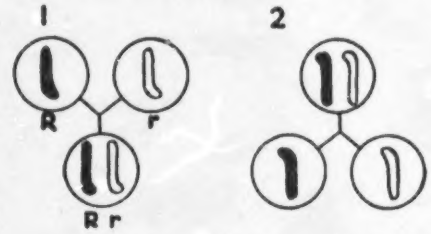
1. The first diagram at the right shows what happens when a pollen grain from a pure red-flowering plant fertilizes an egg cell from a pure white-flowering plant. In this diagram the letter *R* stands for the factor which produces ..... flowers; the letter *r* stands for the factor which produces ..... flowers. Capital letters are used to represent (*dominant, recessive*) ..... factors; small letters represent the ..... factors. The letter used is the initial of the ..... character.

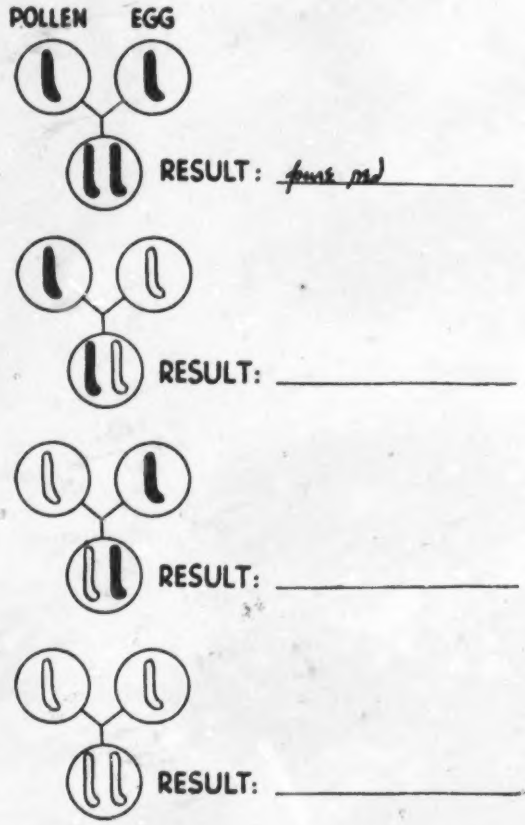
2. What color will the flowers of the F_1 generation have? .....

3. The second diagram represents the formation of pollen grains in the hybrid plant. Because of reduction division, each pollen grain contains only ..... gene for flower color, either the dominant, (*symbol*) ....., or the recessive, ... There are thus (*how many?*) ..... kinds of pollen grains produced by a hybrid plant. Similarly, there are ..... kinds of egg cells produced.

4. The next series of diagrams shows the four possible combinations of pollen grains and egg cells from these hybrids. Next to each diagram, name the type of offspring which results, using the terms *pure red, pure white,* or *hybrid red.*

5. Of the four combinations, how many are pure red? ..... Pure white? ..... Hybrid red? .....

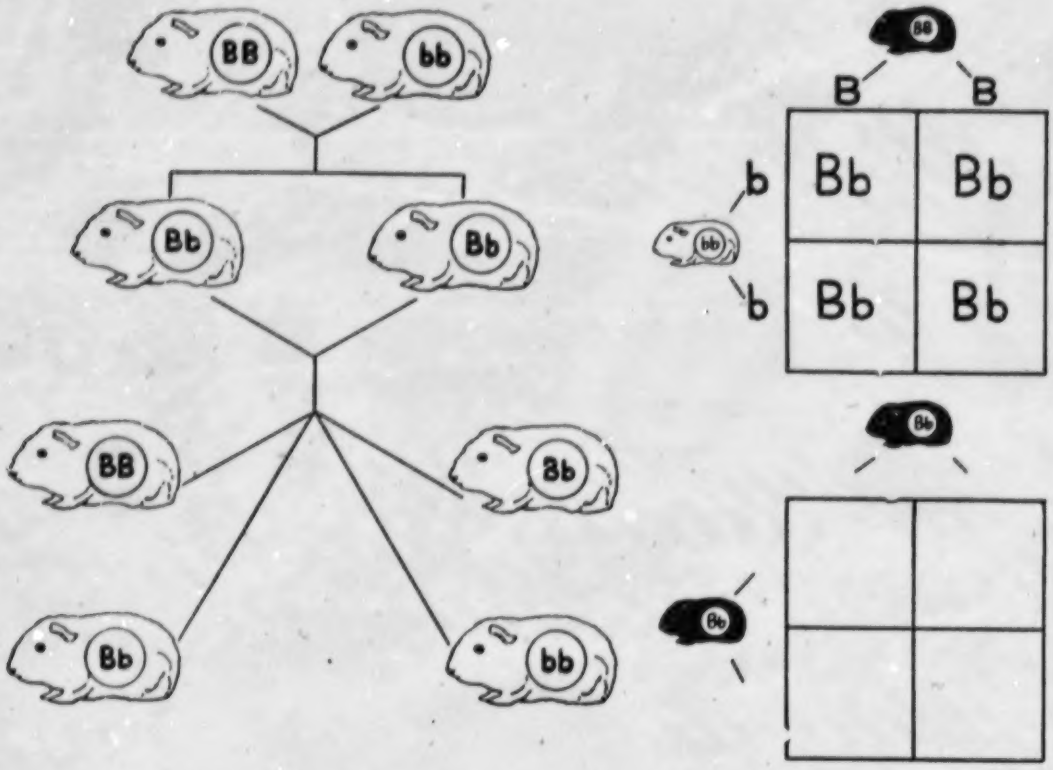




6. GUINEA PIGS ILLUSTRATE MENDEL'S LAWS

Guinea pigs are frequently used for experiments in genetics because they reproduce rapidly and have certain definite characters which can be observed. For example, *black coat* and *white coat* are a pair of contrasting characters; black is dominant. *Smoothness* and *roughness* of coat are another pair; rough coat is dominant.

1. Complete the following diagrams which illustrate the inheritance of hair color in guinea pigs. The parents are a pure black male and a pure white female. Color the animals.



2. The Punnett diagram is a simplified way of determining the genetic make-up of the offspring of any two parents. Complete the diagrams above.

3. In the diagrams above, what does *B* represent? .....

What does *b* represent? .....

4. How many *B* genes are necessary to produce the dominant color? .....

How many *b* genes are necessary to produce the recessive color? .....

5. Give the ratio in the F_2 generation:

Pure Black : Hybrid Black : Pure White

..... : ..... : .....

6. How is the law of segregation illustrated in this exercise? .....

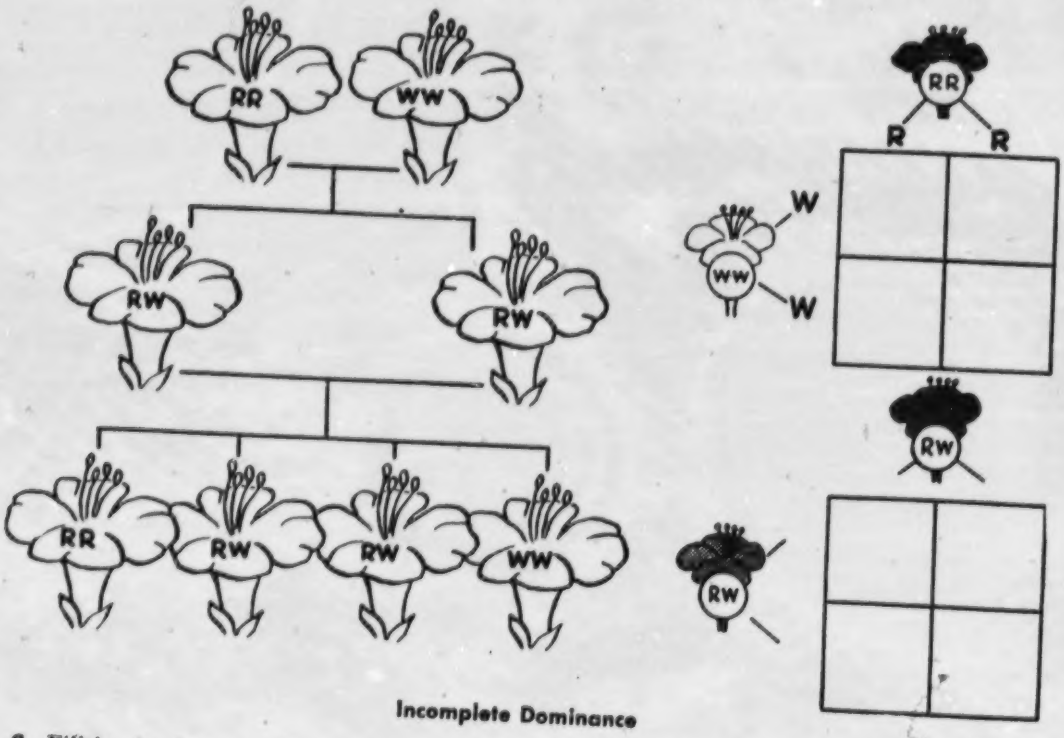
.....

NAME.....DATE.....

7. INCOMPLETE DOMINANCE OR BLENDING

If pure red-flowering and white-flowering four-o'clocks are crossed, the resulting F_1 generation will produce *pink* flowers. Neither parent color shows dominance, but the two colors seem to blend in the hybrid. If the next cross is confined to members of the F_1 generation, the resulting F_2 generation will produce three types of plants: some will have red flowers, some white flowers, and the remainder pink flowers.

1. Use crayons or water colors in coloring the following diagrams to illustrate lack of dominance, or blending. Label *parent type*, *F_1 generation*, and *F_2 generation*.



Incomplete Dominance

2. Fill in the Punnett diagrams for this example of inheritance.

3. Why was the capital letter *W* used to represent the gene for white flowers, instead of a small letter *r**? .....

.....

4. Give the color produced by each combination:

RR:..... *RW:*..... *WW:*.....

5. What is the ratio in the F_2 generation? .....

* Many textbooks do use the symbol *r* for the gene for white flowers. The symbol *W* is used here to emphasize the fact that neither character is dominant.

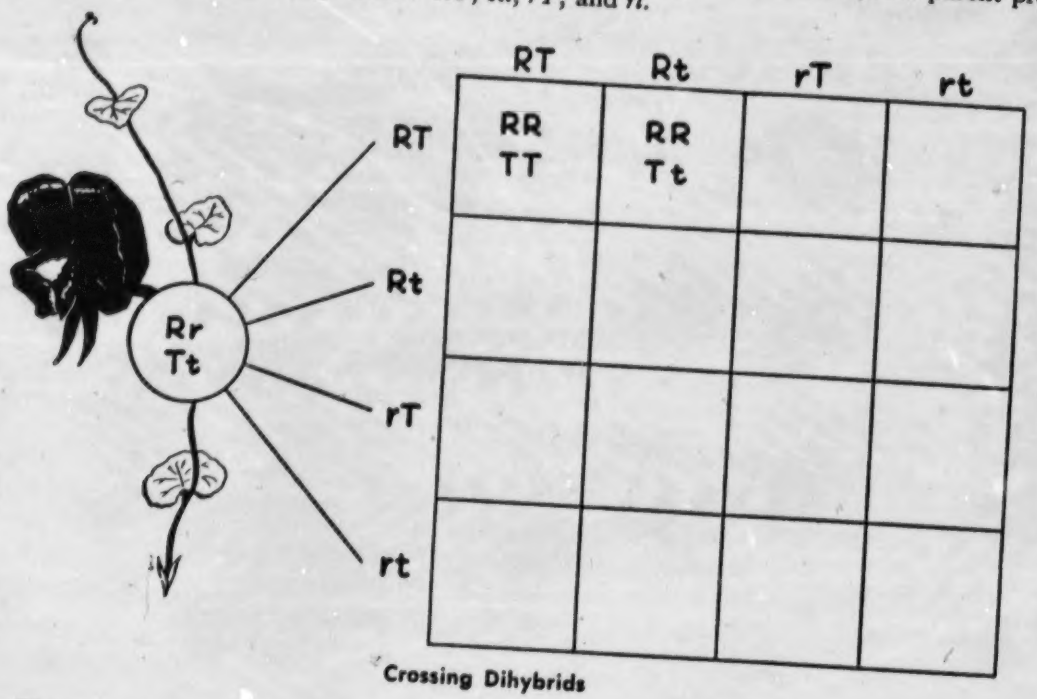
HAVE YOU LEARNED THE MEANINGS OF THESE WORDS?

blending inheritance **incomplete dominance**

8. INHERITANCE OF TWO PAIRS OF CHARACTERS
(Dihybrids)

In one series of experiments, Mendel crossed pure tall, pure red-flowering plants with pure short, pure white-flowering plants. Since tallness is dominant over shortness, and red flowers dominant over white, all offspring in the F_1 generation were tall, with red flowers; but all were *hybrid* in those characters (called *dihybrids*). When these dihybrids were crossed, all possible combinations appeared in the F_2 generation.

1. The Punnett diagram, used in previous lessons, is a great help in determining the ratios in the F_2 generation. Complete the diagram below. Notice that each dihybrid parent produces four different kinds of gametes: *RT*, *Rt*, *rT*, and *rt*.



Crossing Dihybrids

2. There are four different kinds of plants, in appearance, produced in the F_2 generation. Color the squares of the diagram to show which kind is represented by each square. Indicate your color key below:

Tall and Red ☐ *No. of Squares* . . . .

Tall and White ☐ *No. of Squares* . . . .

Short and Red ☐ *No. of Squares* . . . .

Short and White ☐ *No. of Squares* . . . .

3. Count the number of squares with each color, and enter in the spaces above.

OPTIONAL

4. How many different kinds of plants, in genetic make-up, are produced in the F_2 generation? (*Rrtt* is different from *RRtt*, etc.) . . . . . .

HAVE YOU LEARNED THE MEANING OF THIS WORD?

dihybrid (dye-hye′ brid)

GENETIC PROBLEMS

Work each problem separately. When you have worked the problem indicate the genetic laws or principles demonstrated. Be sure you fill out a Punnett Square for each one!

1. Note: In summer squash, white fruit is dominant over yellow.

   a. If a squash plant homozygous for white is crossed with one homozygous for yellow, what will be the genotype of the F_1?

   b. What will be the phenotypes of the F_1?

   c. What will be the genotypes of the F_2?

   d. What is the genotypic ratio of the F_2?

   e. What is the phenotypic ratio of the F_2?

2. A white fruited squash plant when crossed with a yellow fruited one produces offspring about half of which are white and half yellow. What are the genotypes of the parents?

3. Note: In guinea pigs black coat is dominant over white coat.

   a. Cross a homozygous black guinea pig with a homozygous white guinea pig. What are the genotypes and phenotypes of the F_1 generation?

   b. Give the genotypic and phenotypic ratio of the F_1?

4. If a black guinea pig is mated to a white guinea pig and the resulting offspring 8 black and 7 white. What are the genotypes of the parents and the offspring?

5. Note: In guinea pigs, rough coat is dominant over smooth.

   a. Two rough coated guinea pigs when bred together produce 18 rough and 4 smooth offspring. What proportion of these rough offspring may be expected to be homozygous for this character?

6. Note: The polled or hornless condition in cattle (P) is dominant over the horned (p).

   a. A certain polled bull is bred to three cows. With cow A, which is horned, a polled calf is produced; with cow B, also horned, a horned calf is produced; with cow C, which is polled, a horned calf is produced. What are the genotypes of these animals?

7. If a homozygous black rough coated guinea pig is crossed with a homozygous white smooth coated guinea pig, what will be the appearance of the F_1? of the F_2 of the offspring? Determine a genotypic and phenotypic ratio for the F_1 and F_2.

C. Incomplete Dominance

OBJECTIVES:

The student will be able to:

6. define incomplete dominance.

7. determine and project the results of crosses involving incomplete dominant characteristics.

ACTIVITIES:

a. Do "Incomplete Dominance or Blending" (on separate sheet).

b. Work "Problems in Incomplete Dominance" (on separate sheet).

PROBLEMS IN INCOMPLETE DOMINANCE

1. Note: In four o'clock flowers, red flower color is incompletely dominant over white, the heterozygous condition being pink-colored.

   a. If a red flowered four o'clock plant is crossed with a white flowered one, what will be the flower color of the F_1? of the F_2?

   b. If you wanted to produce four o'clock seed all of which would yield pink-flowered plants when sown, how would you do it?

2. Note: In Andalusian fowls the heterozygous condition of the factors for black (B) and white (W) is blue.

   a. What offspring will a blue Andalusian fowl have if bred to birds of the following colors?
      1. black
      2. white
      3. blue

3. Note: In snapdragons red flower color (R) is incompletely dominant over white (W), the heterozygous condition being pink; and the normal broad leaves (B) are incompletely dominant over narrow, grasslike ones (n), the heterozygous condition being intermediate in leaf breadth.

   a. If a red-flowered, broad-leaved plant is crossed with a white-flowered, narrow-leaved one, what will be the appearance of the F_1 and the F_2?

D. Linkage

OBJECTIVES:

The student will be able to:

8. define gene linkage and relate its importance to Mendel's law of independent assortment.

9. define sex linkage.

10. determine and project the results of crosses involving sex linked characteristics.

ACTIVITIES:

a. Read pages 142 and 130 (Gene Linkage and Mendel's Law of Independent Assortment) in the 1969 Modern Biology. Make a full page diagram to illustrate gene linkage and Mendel's Law. On the back discuss the implications of the discovery of gene linkages on Mendel's Law. What do you think would have happened if Mendel had choosen two traits that were linked?

b. Read pp. 135-141 in the 1969 Modern Biology.

c. Do lab 10-1 "Sex Chromosomes and Linkage".

d. Work "Sex Linked Problems" (on separate sheet).

10-1

SEX CHROMOSOMES AND LINKAGE

Purpose

To study the inheritance of six and sex-linked traits.

Related Information

Each human body cell contains 23 pairs of chromosomes. One of the pairs is different in the male and female. The members of this pair are referred to as the sex chromosomes. When a gene is carried on a sex chromosome, it is said to be sex-linked.

Part 1 DIAGRAMMING SEX DETERMINATION

The two sex chromosomes of the female are similar and are referred to as X chromosomes. In the male the sex chromosomes consist of an X chromosome and a Y chromosome.

Materials

no materials or apparatus required

Procedure and Observations

Using a Punnett square, diagram sex determination in man in the space provided. (a) What is the genotype of the female? ..... (b) The male? ..... (c) What is the probability that the offspring will be male? ..... (d) Female? ..... (e) Why is it impossible to predict the sex of the offspring? .....

♂ XY × ♀ XX

Female → Chromosomes Male ↷		

Part 2 DIAGRAMMING SEX LINKAGE

In human beings, the genes controlling color vision are located on the X chromosomes. The gene for normal color vision is dominant to the gene for color blindness. We can represent this as X^C for normal dominant color vision, and X^c for the color-blind recessive. Therefore, $X^C X^c$ would represent a female with normal color vision who is a carrier of the recessive gene for color blindness. A female with normal color vision who is not a carrier of the gene for color blindness is represented by $X^C X^C$. $X^c X^c$ represents a color-blind female.

In males, $X^C Y^-$ indicates normal color vision and $X^c Y^-$ indicates color blindness. The Y chromosome does not carry a matching gene for color vision.

Materials

no materials or apparatus required

Procedure and Observations

Fill in the following Punnett square, diagramming inheritance of color-blindness in man.

X^cY X X^CX^c

Female → Chromosomes Male ↷		

(a) Summarize the sex and color vision ability of the offspring. .....

.....

.....

.....

Part 3 DEMONSTRATING A SEX-LINKED TRAIT USING "PIPE CLEANER" CHROMOSOMES

In this part, you will set up a graphic demonstration to illustrate the masking of one gene by another, since you are unable to perform crosses between humans to study the inheritance of genes. You will use pipe cleaners to represent the sex chromosomes and test tubes for the cells of the body.

Materials

four 6-inch test tubes
white pipe cleaners
10% hydrochloric acid solution
weak brom thymol blue solution
1% sodium hydroxide solution

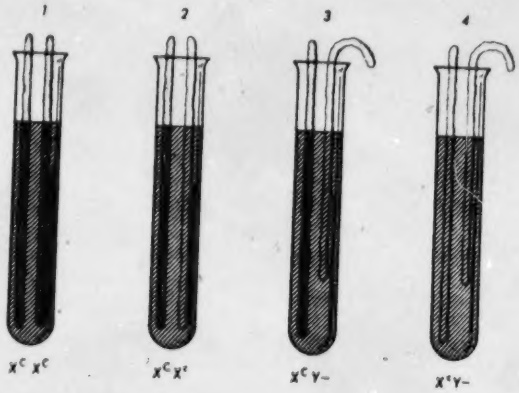
Procedure and Observations

Soak pipe cleaners that will represent the X^C chromosomes in a 10% hydrochloric acid solution for about an hour. Soak the pipe cleaners that are to represent the X^c chromosomes in a 1% sodium hydroxide solution for about an hour. Leave the pipe cleaners in their respective solutions until you are ready to use them. Bend some pipe cleaners to resemble a cane. These are left untreated and represent the Y chromosome.

Fill four test tubes two-thirds full of the brom thymol blue solution. This solution serves as an indicator to demonstrate the masking of the genes when a recessive and a dominant one are present in the same cell. The solution turns yellow in the presence of a base (sodium hydroxide). Number the test tube "cells" 1–4.

Distribute the variously treated pipe cleaner "chromosomes" as follows: two acid in tube 1; an acid and a sodium hydroxide in tube 2; an acid and an untreated one in tube 3; and a sodium hydroxide and untreated one in tube 4, as shown.

Observe any color change that occurs in the tubes. Record the results and conclusions in the table provided.



Technique for setting up the test tube "cells" and pipe cleaner "chromosomes"

Genes	*Color change*	*Color vision*	*Sex*
X^CX^C			
X^CX^c			
X^CY^-			
X^cY^-			

(a) What percent of the males in your demonstration would be color-blind? .....

(b) What percent of the females would be color-blind? ..... (c) Explain your answer.

.....

Work out a cross between a color-blind male and a female who is a carrier of the color-blind gene. Use a second set of pipe cleaner "chromosomes" and test-tube "cells." Prepare your own table and record your results. (d) What percent of the females would be color-blind in this cross?

..... (e) Explain. .....

(f) What percent of the males would be color-blind? ..... (g) Explain. .....

.....

Summary

Explain why only a small percent of the women in the population are color-blind. .....

.....

.....

.....

.....

SEX LINKED PROBLEMS

1. A girl of normal vision whose father was color blind marries a man of normal vision whose father was also color blind. What type of vision will be expected in their offspring?

2. A color-blind man marries a woman of normal vision. They have sons and daughters, all of normal vision; and all of whom marry normal persons. Where among the grandchildren may color blindness be expected to appear?

3. A man and woman, both of normal vision have 1.) a color-blind son who has a daughter of normal vision; 2.) a daughter of normal vision has one colorblind and one normal son; and 3.) another daughter of normal vision who has five sons, all normal. What are the genotypes of grandparents, children and grandchildren?

4. A man's maternal grandmother had normal vision; his material grandfather was colorblind; his mother is colorblind; his father is of normal vision. What are the genotypes, as to vision of the two parents and grandparents mentioned? What type of vision has this man himself? What type have his sisters? If he should marry a woman genotypically like one of his sisters, what type of vision would be expected in the offspring?

UNIT OBJECTIVES

The student will be able to:

1. summarize the work of Gregor Mendel and relate its importance to the field of genetics.

2. explain and diagram these basic genetic principles:

   a. Concept of unit characters
   b. Principles of dominance and recessiveness
   c. Law of Segregation
   d. Law of Independent Assortment

3. work genetic problems of both monohybrid and dihybrid crosses for both homozygous and heterozygous traits.

4. use and fill out a Punnett Square.

5. determine genotypic and phenotypic ratios for genetic problems presented to you.

6. define incomplete dominance.

7. determine and project the results of crosses involving incompletely dominant characteristics.

8. define gene linkage and relate its importance to Mendel's law of independent assortment.

9. define sex linkage.

10. determine and project the results of crosses involving sex linked characteristics.

A. THE WORK OF GREGOR MENDEL

ACTIVITIES

a. Another text or edition of Modern Biology may be substituted

b. _____

c. _____

d. Lab 9-2 from Biology Investigations by Otto and Towle
need genetic corn with these ratios
1:1 purple to nonpurple
3:1 purple to nonpurple
9:3:3:1 purple: smooth: yellow: shrunken
straight pins

B. PUTTING THESE LAWS TO WORK

ACTIVITIES

e. from Laboratory Activity Manual for Biology by Zeichner & Berman.

f. from Discovery Problems in Biology by Bagby, Cope, Hann and Stoddard.

g. from Discovery Problems in Biology.

h. _____

C. INCOMPLETE DOMINANCE

i. from Discovery Problems. Note: Biology Investigations (Otto, Towle) also has lab on this 9-3.

j. _____

D. LINKAGE

ACTIVITIES

k. Once again, substitute if necessary.

l. same

m. from Biology Investigations
need (per team or individual)
4 six inch test tubes
white pipe cleaners
10% HCl solution
weak bromthymol blue solution
1% NaOH solution

BIBLIOGRAPHY

(Books containing parallel information)

Biology by Smallwood and Green, Silver Burdette

Biology : An Inquiry Into the Nature of Life by Weinberg, Allyn and Bacon, Inc.

Biology and Human Progress by Eisman and Tanzer, Prentice Hall.

BSCS Green Version by BSCS Staff, Rand McNally.

Modern Biology by Otto and Towle, Holt, Rinehart, Winston. (several editions)

Lab Manuals

Biology Investigations by Otto, Towle, Crider, Holt, Rinehart and Winston.

Discovery Problems in Biology by Bagby, Cope, Hann, Stoddard, College Entrance Book Company.

Laboratory Activity Manual for Biology by Zeichner and Berman, College Entrance Book Company.

Note:

Audio-Visuals on this are in general-poor. The genetics films from the IMC are very difficult and are not recommended.

One good film "The Thread of Life" is available through Bell Telephone Company.

Note:

Another text worth investigation for the middle ability student might be Biology and Human Progress by Eisman and Tanzer, pub. Prentice Hall. Also - some grade 7 Life Science texts may have reading material appropriate to this student.

SCIENCE MINI-COURSES

	Prepared by
PHYSICAL SCIENCE	
ELECTRICITY: Part 1 (Types of Generation of Electricity)	Marvin Blickenstaff
ELECTRICITY: Part 2 (The Control and Measurement of Electricity	Marvin Blickenstaff
ELECTRICITY: Part 3 (Applications for Electricity)	Marvin Blickenstaff
CAN YOU HEAR MY VIBES? (A Mini-course on Sound)	Charles Buffington
LENSES AND THEIR USES	Beverly Stonestreet
WHAT IS IT? Identification of an Unknown Chemical Substance	Jane Tritt
BIOLOGY	
A VERY COMPLEX MOLECULE: D.N.A. The Substance that Carries Heredity	Paul Cook
Controlling the CODE OF LIFE	Paul Cook
Paleo Biology – BONES: Clues to Mankind's Past	Janet Owens
A Field Study in HUMAN ECOLOGY	Janet Owens
Basic Principles of GENETICS	Sharon Sheffield
HUMAN GENETICS – Mendel's Laws Applied to You	Sharon Sheffield
SCIENCE SURVEY	
WEATHER Instruments	John Fradiska
TOPOGRAPHIC Maps	John Geist and John Fradiska
CHEMISTRY	
WATER	Ross Foltz
PHYSICS	
PHYSICAL OPTICS	Walt Brilhart